Concentrating Photovoltaic (CPV) R&D

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Concentrating Solar Power (CSP) Peer Review

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CONCENTRATING SOLAR POWER

Sun♦Lab

Sandia National Laboratories, Albuquerque, NM
National Renewable Energy Laboratory, Golden CO

Why CPV?

- CPV offers an exciting new opportunity to apply new cell technology as a viable alternative to dish Stirling engines
- CPV advantages
  - potential for >40% cell efficiency in the long term (25% now)
  - no moving parts
  - no intervening heat transfer surface
  - near-ambient temperature operation
  - no thermal mass, fast response: annual ~ peak efficiency
  - concentration reduces cost of cells relative to optics
  - scalable to a range of sizes
- Various configurations possible
  - Large reflective dish with dense-packed array
  - Multiple, single cell concentrators (reflective or refractive)

Existing industrial examples

Solar Systems Ltd

- 20 kW Mark 1 (19%)
- 25 kW Mark 3 (130 m^2)
- Sunpower Si cells
- Claim $4/W installed system cost today

Amonix

- 25 kW MegaModule™
- 5 kW Fresnel-based modules
- High efficiency Si cells
- 500 kW planned for APS
- 16% average AC efficiency

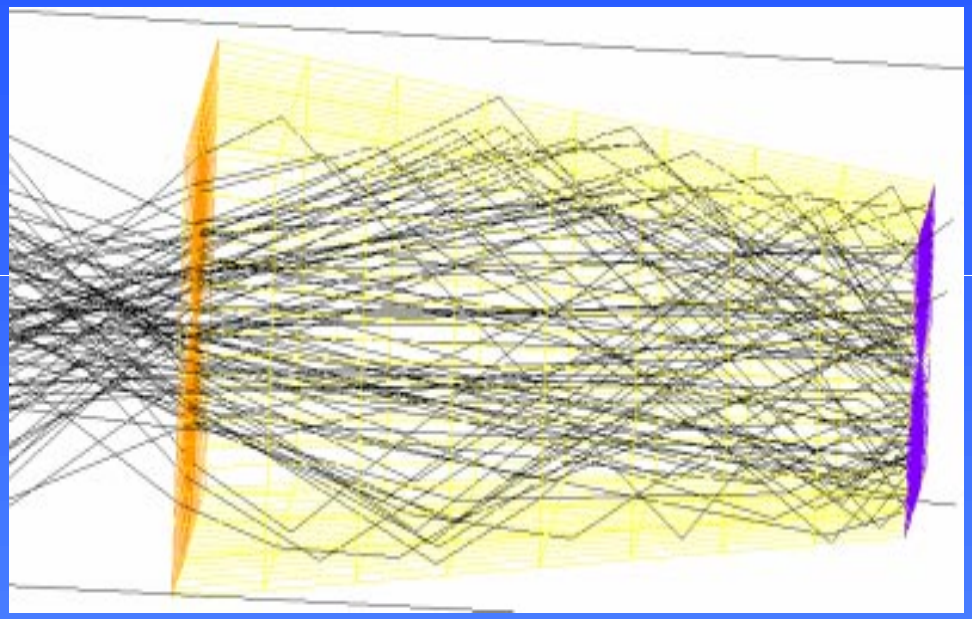
Current Activities

- Flux uniformity
  - Uniform flux maximizes system performance
    - more important for dense-packed arrays
    - wired in series, cell with lowest flux drives array output
- Receiver development
  - Improvements in current dense-packed arrays
    - packing factor and packaging
    - thermal control
  - Innovative new designs
- System development
  - CTek/APS 2 kW dish
    - Amonix and/or Spectrolab array
  - SAIC dish retrofit/redesign for CPV

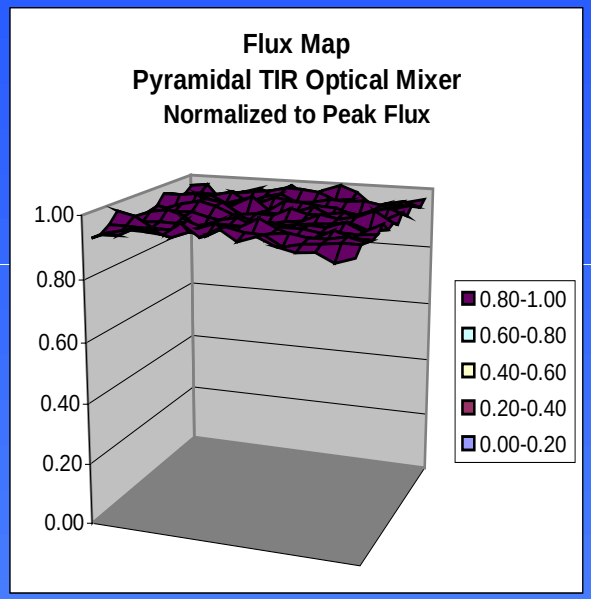
Flux Uniformity Status

- Evaluated and documented subcontracted analysis for reflective dishes with dense packed arrays
  - Duke Solar
    - refractive secondaries
  - Optical Research Associates
    - reflective secondaries, primary shape modifications
- Plenty of good ideas but will need to wait until programmatic funding issues resolved

Duke Solar



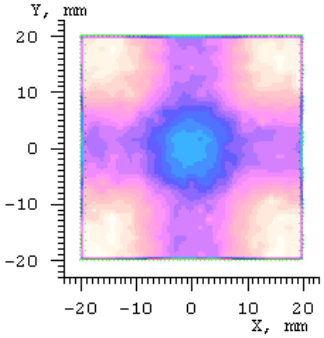
Refractive TIR mixer



Uniformity results

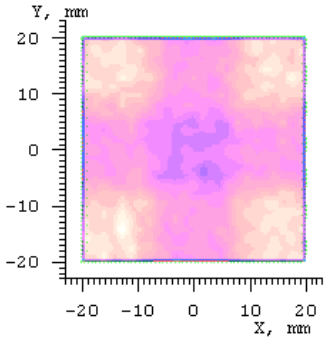
Optical Research Associates

L=21 mm

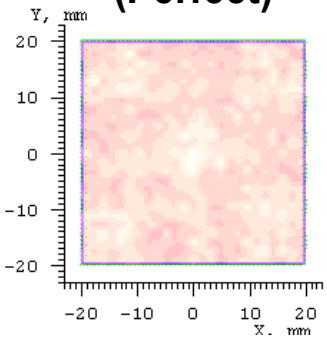


Dark Center
Bright Corners

L=23 mm

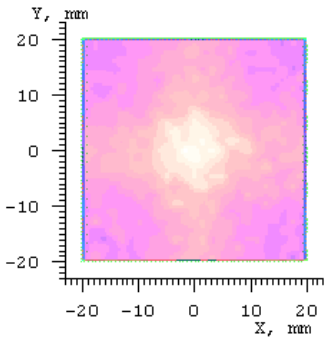


L=25 mm (Perfect)

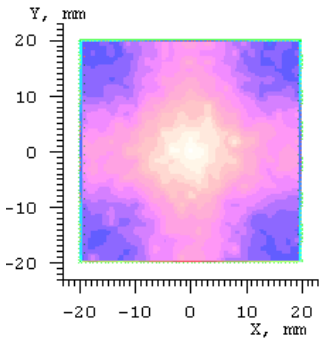


Uniform
Irradiance

L=27 mm



L=29 mm



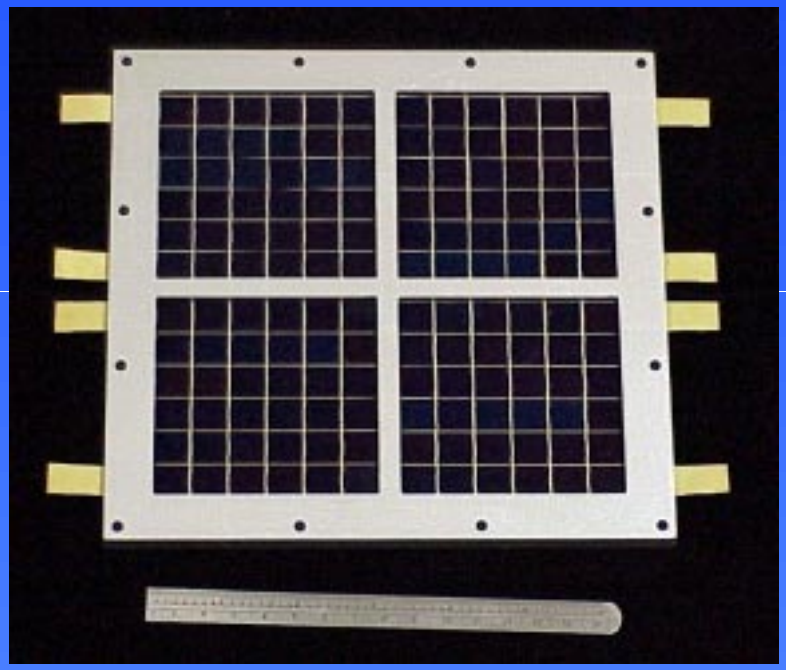
Bright Center
Dark Corners

Sensitivity to Changing Length of Secondary Tube

Receiver design status

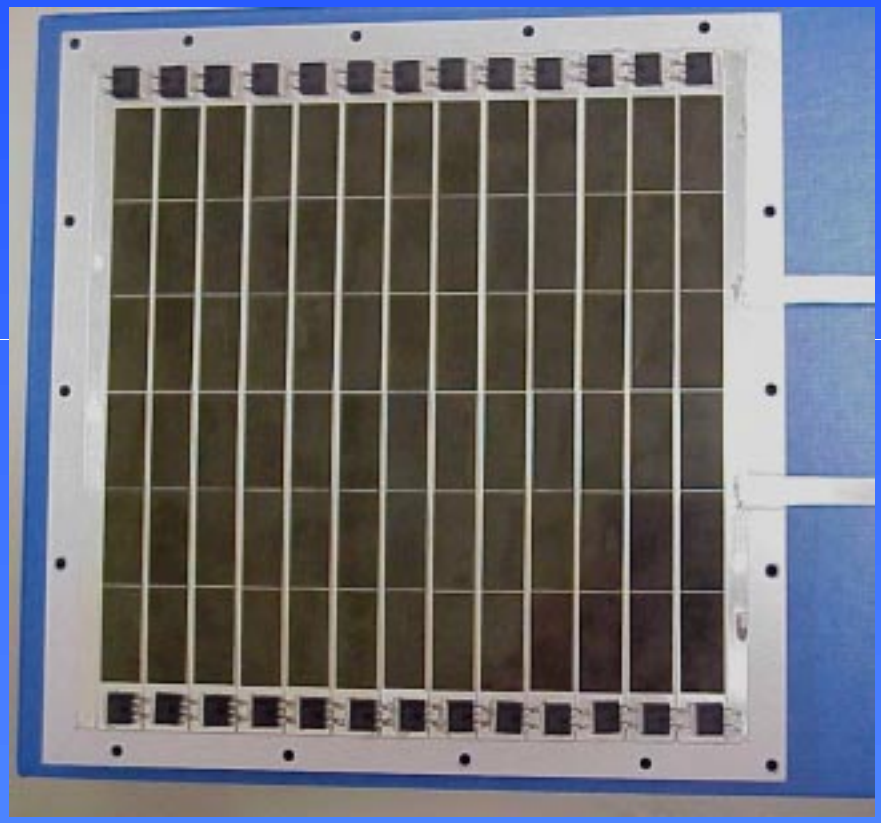
- Solicitation for 1 kW modules
  - Amonix (current technology, robust cells)
    - Dense-packed Si array, module packaging, water cooling, moving forward with hardware
  - Spectrolab (high efficiency future, more developmental)
    - Dense-packed multi-junction array, module packaging, water cooling, move to hardware this FY
  - United Innovations (very high efficiency potential, highest risk)
    - Unique cavity design using multiple cells, selective filters, move to hardware this FY
- Testing of modules at HFSF
  - Designed/fabricating a secondary to deliver uniform flux

Amonix Dense-Packed Array



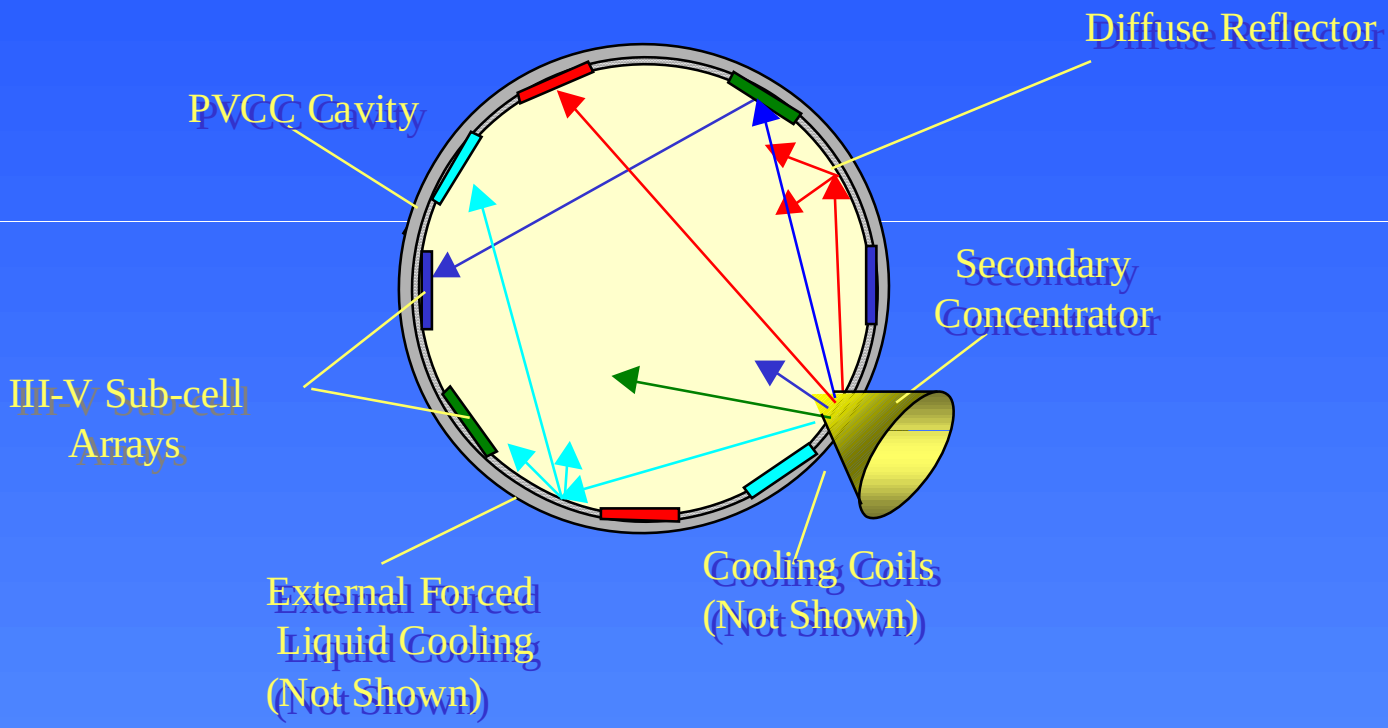
Quad array delivered to Ctek

Spectrolab Dense-Packed Array

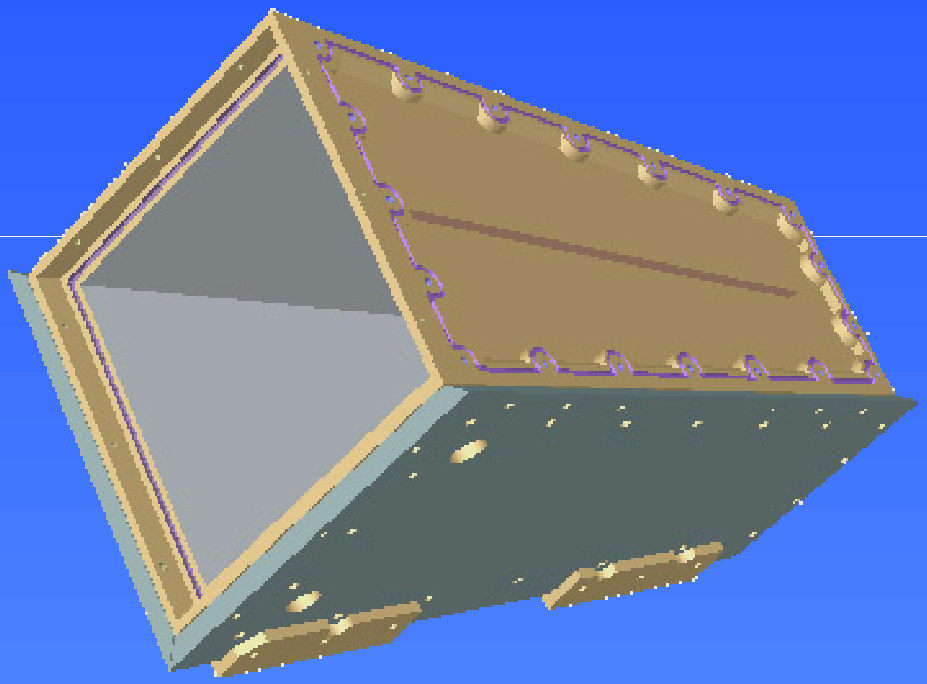


High-efficiency multi-junction cells

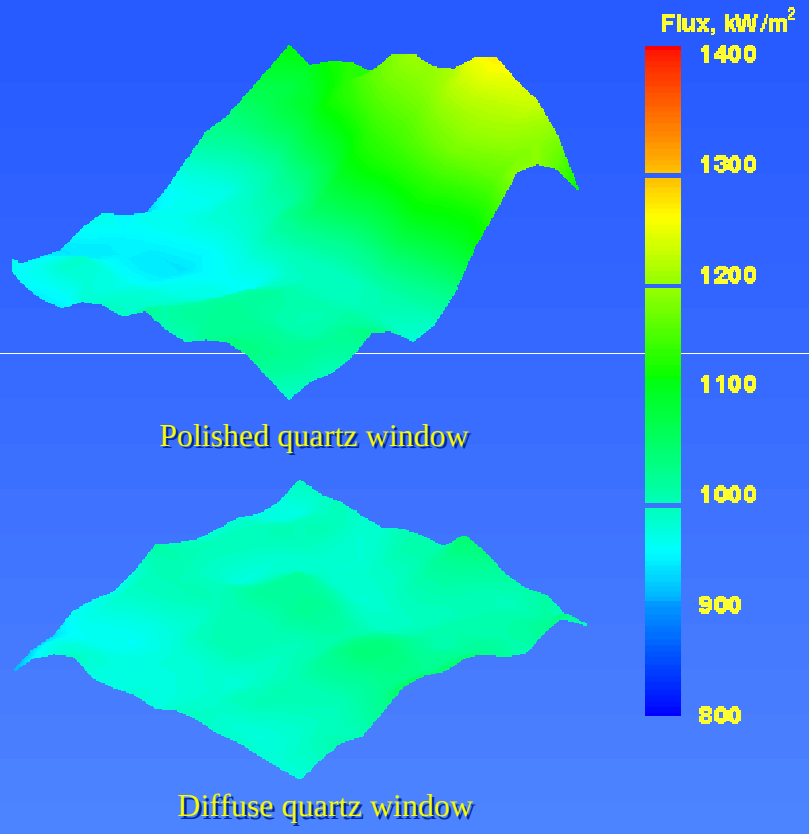
United Innovations Concept



Secondary for CPV Testing at HFSF



Truncated pyramid, reflective walls



Predicted flux map from SolTrace

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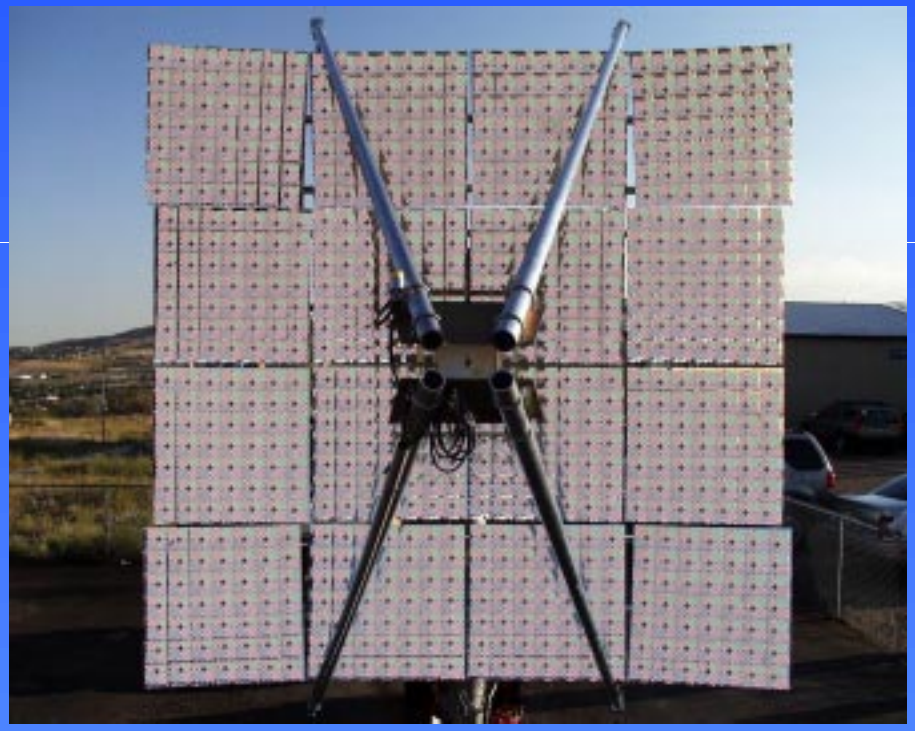
System Development Status

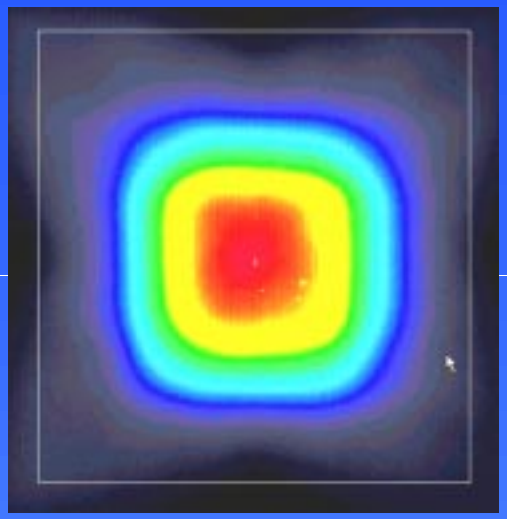
- CTek dish installed at NREL
  - Dish, drive, controller in September
  - Array, secondary, sun sensor expected December
  - APS trailer to follow
- Current test activities
  - Dish facet alignment
  - Flux mapping of primary
- Planned tests
  - Flux mapping of secondary
  - Array performance
- SAIC Dish redesign

CTek

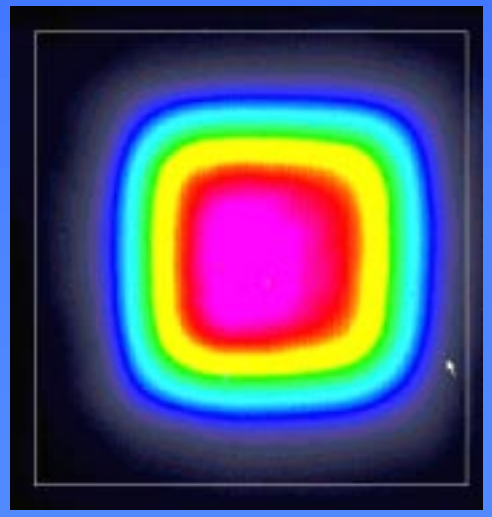
Flux maps



2f alignment



Post 2f



Post on-sun

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SAIC Dish

Prototype CPV demonstration planned

New dish design can be tailored for CPV

Opportunities and Issues

- Continue component performance improvement
- Integrate components into improved systems
- Demonstrate performance and reliability
- Scale up to larger sizes
- Should continue a range of concepts
  - Multiple mini-concentrators
  - Dense-packed array systems
  - Innovative receiver designs
  - Expand thermal control activities
    - apply new technology to cooling of arrays